P02153647BUS

IN THE U[redacted]ED STATES PATENTS AND TRADE[redacted]K OFFICE

JC14 Rec'd PCT/PTO 25 MAY 2005

I, Wilfried Adam, declare:

1. That I am a citizen of Germany and a translator to Jürgen Leineweber, Dipl.-Phys., Aggerstr. 24, D-50859 Köln, Germany.

2. That I am well acquainted with the German and English languages.

3. That the attached is a true translation into the English language of the accompanying document P02.15 WO.

Dated: May 3, 2005

W. Adam

Ball Bearing and a Vacuum Pump that is Equipped with a Bearing of this Type

The present invention relates to a ball bearing having an inner race and an outer race. Moreover, the present invention relates to a vacuum pump, preferably a turbomolecular vacuum pump equipped with a ball bearing of this type.

Ball bearings of the type stated serve the purpose of holding and guiding rotatable machinery components, generally shafts. The outer race – in the instance of inverted bearings also the inner race – is supported by a fixed component (bearing disk, housing or alike). Generally bearings of this type are oil- or grease-lubricated bearings. The present invention may also be applied to grease-free bearings. Equally the present invention is independent of whether the bearings are implemented with or without a cage.

It is the task of the present invention to implement a ball bearing of the aforementioned kind such that in the event of a failure of the bearing and guidance of the rotating component damage to, respectively within the machine is avoided.

This task is solved by the present invention through the characterising features and measures of the patent claims.

In that the gap between surfaces which oppose each other is relatively small, these surfaces assume in the instance of uncontrolled movements of the rotating unit the function of emergency bearing surfaces. The rotating unit is guided in a single emergency rundown to standstill without the occurrence of a rotor crash. The friction produced during an emergency rundown is so great that the installed drive power will no longer suffice. The converter of the drive unit switches to failure so that standstill is attained rapidly.

Further advantages and details of the present invention shall be explained with reference to the examples of embodiments depicted in the drawing figures 1 to 5. Depicted is/are in

- drawing figures 1 to 4 ball bearings with differently designed emergency bearing surfaces and
- drawing figure 5 a molecular drag vacuum pump equipped with emergency bearing surfaces in accordance with the present invention.

The bearings 1 depicted in the drawing figures 1 to 4 exhibit each an inner bearing race 2, an outer bearing race 3, balls 4 and a cage 5. The axis of the bearing 1 is in each case designated as 6. In the axial direction (in the drawing figures 1 to 4 at the top in each instance) the inner chamber 7 of the ball bearing 1 is substantially sealed by a bearing cover 8 and specifically employing a snap ring 10 which is clamped within an inner groove 11 in the outer bearing race 3. Commonly bearing covers of this type are provided to both sides of the balls 4.

In order to form the emergency bearing surfaces 14, 15 in accordance with the present invention one or both bearing races 2, 3 are equipped with ring-shaped projections which – when arranged on the side opposing the bearing cover 8 simultaneously provide the function of a second bearing cover 8. In the solution in accordance with drawing figure 1 the outer bearing race 3 is provided on its side opposing the bearing cover 8 with a projection 16 extending in the direction of the inner race 2. The inner surface of said outer bearing race 3 forms with reference to the axis 6 the cylindrical emergency bearing surface 14. The section of the outer surface of the inner race 2 opposing said surface 14 is the second emergency bearing surface 15.

In the solution in accordance with drawing figure 2, the inner race 2 is equipped with a projection 17 extending[1)] radially towards the outside. The outer surface of the inner race 2 and a part of the inner surface of outer race 3 also form cylindrical emergency bearing surfaces 14, 15.

In the solutions in accordance with drawing figures 3 and 4 the inner bearing race 2 and the outer bearing race 3 are equipped with projections 18, 19 respectively 21, 22. The emergency bearing surfaces 14, 15 opposing each other exhibit a stepped cross-section (drawing figure 3) respectively form with the axis 6 the angle α. In this manner emergency bearing surfaces are created which not only become effective in the instance of a failure of the radial guidance of the rotating system by the bearings but also in the instance of an axial failure.

The size of the gap 24 between the emergency bearing surfaces 14, 15 should be as small as possible. However, the size of said the gap must not fall below the permissible bearing tolerances. The fact that the bearing tolerances are frequently different in the radial and the axial direction needs to be taken into account when selecting the gap size.

Drawing figure 5 depicts as an example for a molecular drag vacuum pump a turbomolecular pump 25 the stator of which is designated as 26 and the rotor of which is designated as 27. Said pump is designed by way of a compound pump and is equipped with a turbomolecular pumping stage 28 equipped with blades and a molecular pumping stage 29 equipped with a thread. The rotor 27 is partly of a bell-shaped design. Within, respectively slightly below the space 31 encompassed by the bell, the rotor is supported rotatably through the shaft 34 in the bearings 35 and 36. Moreover, there is accommodated within the space 31 the electric drive motor, its stator pack which is designated as 37 and the rotor pack which is designated as 38. The bearings 35, 36 and the rotor stator 37 are supported by a sleeve-like carrier 39.

---

[1] **Translator's note:** The German text states "... erstreckende erstreckenden... " here whereas "... erstreckenden ..." would make for a complete sentence. Therefore the latter has been assumed for the translation.

For the purpose of supplying the bearings 35 and 36 with a lubricant, a vessel 41 filled with oil 40 is affixed underneath the turbomolecular pump 25[2]. The drive shaft 34, the lower end of which is immersed in the oil exhibits an inner coaxial bore 42 which owing to the conically expanding bottom section 43 effects pumping of the lubricating oil towards the top. Through cross bores 44 the oil first arrives at the upper bearing 35 and there flows, due to the effect of gravity, through the bottom bearing 36 back into the oil vessel.

Through the forevacuum port 45 and the line 46 the turbomolecular pump 25[3] is connected to the forevacuum pumping facility 47. Since there exists between the motor/bearing chamber 31 and the forevacuum port 45 a connection, there also prevails in space 31 the necessary forevacuum pressure needed to operate the turbomolecular pump. In order to prevent corrosive gases being pumped by the turbomolecular pump from entering into the bearing chamber 31, a purge gas facility is provided which initially comprises the gas admission pipe 48 opening out into the bearing chamber. For the purpose of admitting the purge gas in a controlled manner said gas inlet pipe 48 exhibits a valve 50. The purge gas (N_2 for example) entering into the motor/bearing chamber 31 flows through the motor as well as the upper bearing 35 and passes outside the bearing carrier 39 to the discharge port 45. Thus the entry of corrosive gases, which are being pumped by the turbomolecular pump 25, into the motor/bearing chamber 31 is prevented.

---

2) **Translator's note:** The German text states "31" here whereas "25" would be more in line with the drawing figures and the remaining text. Therefore "25" has been assumed for the translation.

3) **Translator's note:** The German text states "31" here whereas "25" would be more in line with the drawing figures and the remaining text. Therefore "25" has been assumed for the translation.

Within the scope of the present invention one bearing or both bearings 35, 36 has/have been designed (not depicted in detail) as depicted in one of the drawing figures 1 to 4. An advantage of this measure is that in the instance of a failing bearing, the active pumping surfaces (blades of the rotor/stator thread) are not damaged. The gap 24 between the emergency bearing surfaces 14, 15 defines in the instance of a failed bearing the maximum deflection of the rotor 27 from its nominal position. Correspondingly narrow also the distances between the active pumping surfaces can be selected. The smaller these distances, the better the properties of the pump. Moreover, the fact, that between the bearing races 2, 3 at least for bearing 35 there exists a narrow relatively long gap 24, offers the advantage of a considerable reduction in the rate of the purge gas flowing through the bearing. Finally, the projections at the bearing races 2, 3 permit larger contact surfaces which effect an improvement in the dissipation of heat from the bearing.

The gap 24 needs to be selected corresponding to the bearing tolerances. In the instance of pumps of the described kind, the gap width is expediently less than 0.1 preferably less than 0.05 mm. The size of the emergency bearing surfaces is defined through the axial extension of the gap. Said extension should not drop below 1.5 mm, in the case of oblique or stepped emergency bearing surfaces correspondingly larger.

It is of importance that in the instance of a failed bearing the friction produced by the emergency bearing surfaces 14, 15 is high so that the drive for the rotating system can switch to failure. The friction characteristic of the emergency bearing surfaces 14, 15 depends on the material (expediently hardened rolling bearing steel). By coating one or both emergency bearing surfaces (with MoS_2, Teflon, for example) it

is not only possible to increase the amount of friction but also reduce the tendency of seizing for the given pair of materials.